Memorandum

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Date: January 12, 2010

To: Steve Hitch, City of Redmond

cc: Larry Grimm, Otak

From: Patty Dillon

Subject: Overlake HSPF Model Validation

Pages: 6

Northwest Hydraulic Consultants (NHC) was retained by the City of Redmond (City) to develop hydrologic and hydraulic models for the City's Overlake drainage basin, and to provide design support to Otak Inc. (Otak) in the designing long-term flow control solutions for the basin. NHC previously developed and calibrated an HSPF model of existing basin conditions, as documented in a May 2009 report. The model was subsequently updated to reflect more detailed surface geology mapping for the Overlake basin (Troost and Wisher, 2009), as documented in NHC's September 2009 memorandum.

Since the September update, the Overlake basin has experienced two additional moderate to large storm events, including the largest peak recorded since the installation of the gage in February 2009 at the Sears parking lot monitoring location. This memorandum documents further HSPF model validation and associated minor updates.

HSPF Model Updates

Land Surface Modeling

There were no significant changes to the subbasin, soils, or land use data or approach in this update. Please refer to NHC's May 2009 report and September 2009 update for full discussion of these model components.

For the purpose of modeling one of Otak's design alternatives in earlier work, the large subbasin R-1a was split just south of NE 24th Street. The upper portion of the basin, now subbasin R-1d, covers 78.6 acres, with the remaining 33.3 acres in a smaller subbasin R-1a. This change was carried over for the current model validation assessment.

Runoff and Flow Routing

Based on initial simulations showing much higher peaks than observed for the October 17, 2009 event, NHC revisited the storage-discharge tables (FTABLEs) representing existing storage in the

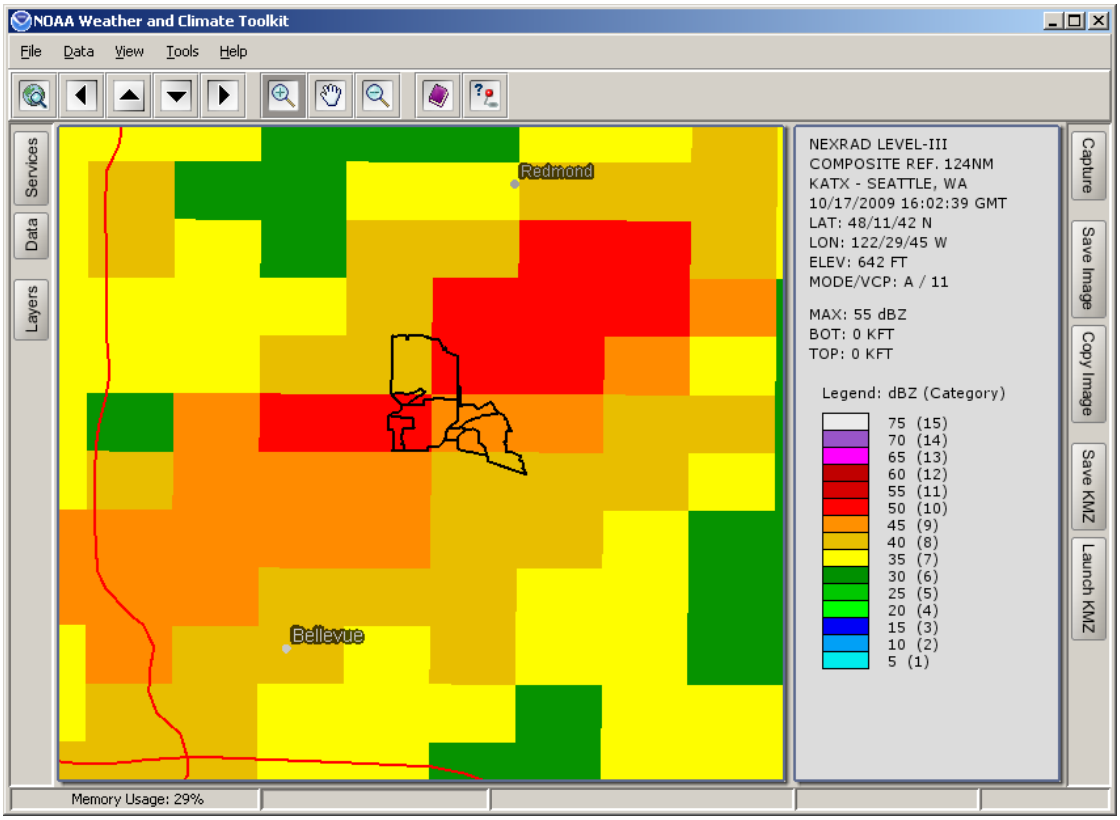
basin. New FTABLEs were generated from the PC-SWMM model for subbasins R-1a and R-1d, replacing estimated existing storage FTABLEs from previous work. Additionally, the FTABLE for the large upper subbasin, R-2a, was also adjusted based on storage-discharge data output from the latest version of the the PC-SWMM model. For all three subbasins, the current version of the SWMM model indicated more storage volume than had previously been assumed, based on facilities and information added to the SWMM model since the last HSPF model update. Increased storage is consistent with reductions in peak flows.

October 17 Event Rainfall Investigation

The Overlake rain gage recorded very high rainfall (0.17 and 0.21 inches) for two consecutive 10-minute time steps on October 17. Simulations using these rainfall amounts applied across the basin resulted in a 10-minute peak flow of 108 cfs, compared to the gaged 15-minute peak of 89 cfs. Because this type of short-intensity rainfall burst is often very localized, NHC obtained NEXRAD radar data to assess whether application of these peak totals over the whole basin at one time was appropriate.

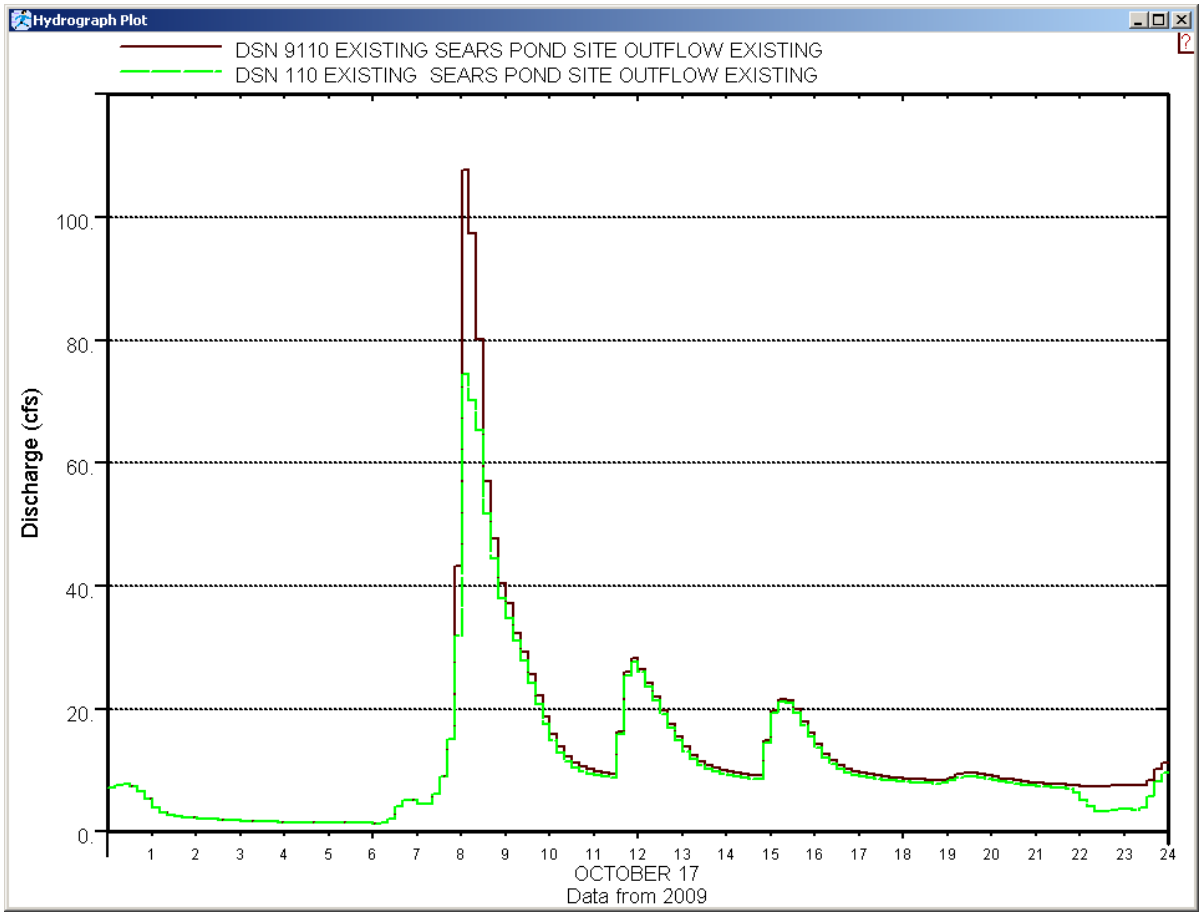
NHC downloaded NEXRAD composite reflectance data for the peak rainfall period on October 17, and evaluated reflectance patterns over the basin as a whole compared to the rain gage location near the southeast corner of the basin. For the peak rainfall period, reflectance values (which correlate non-linearly with rainfall intensity) were higher over the gage than at other locations in the basin or over the basin as a whole (Figure 1).

Figure 1. NEXRAD Image for October 17 Rainfall Peak



Using techniques previously employed in work for the City of Seattle and the reflectance-intensity relationship used by the Seattle National Weather Service office, NHC estimated basin average 10-minute rainfall amounts for the 45-minute period containing the peak rainfall. These were remarkably consistent with the gage amounts except for the two highest values noted above. NHC created an alternative rainfall record substituting the NEXRAD-based averages for the two gage values for use in further model calibration. Figure 2 shows a comparison of the simulated 10-minute flow hydrographs at the gage with the original (DSN 9110) and modified (DSN 110) rainfall. The modified rainfall record reduces the peak 10-minute flow by more than 25 percent to 74 cfs.

Figure 2. Simulation Comparison using Raw, Gaged Rainfall Data and NEXRAD-modified Rainfall Data for the October 17, 2009 Event



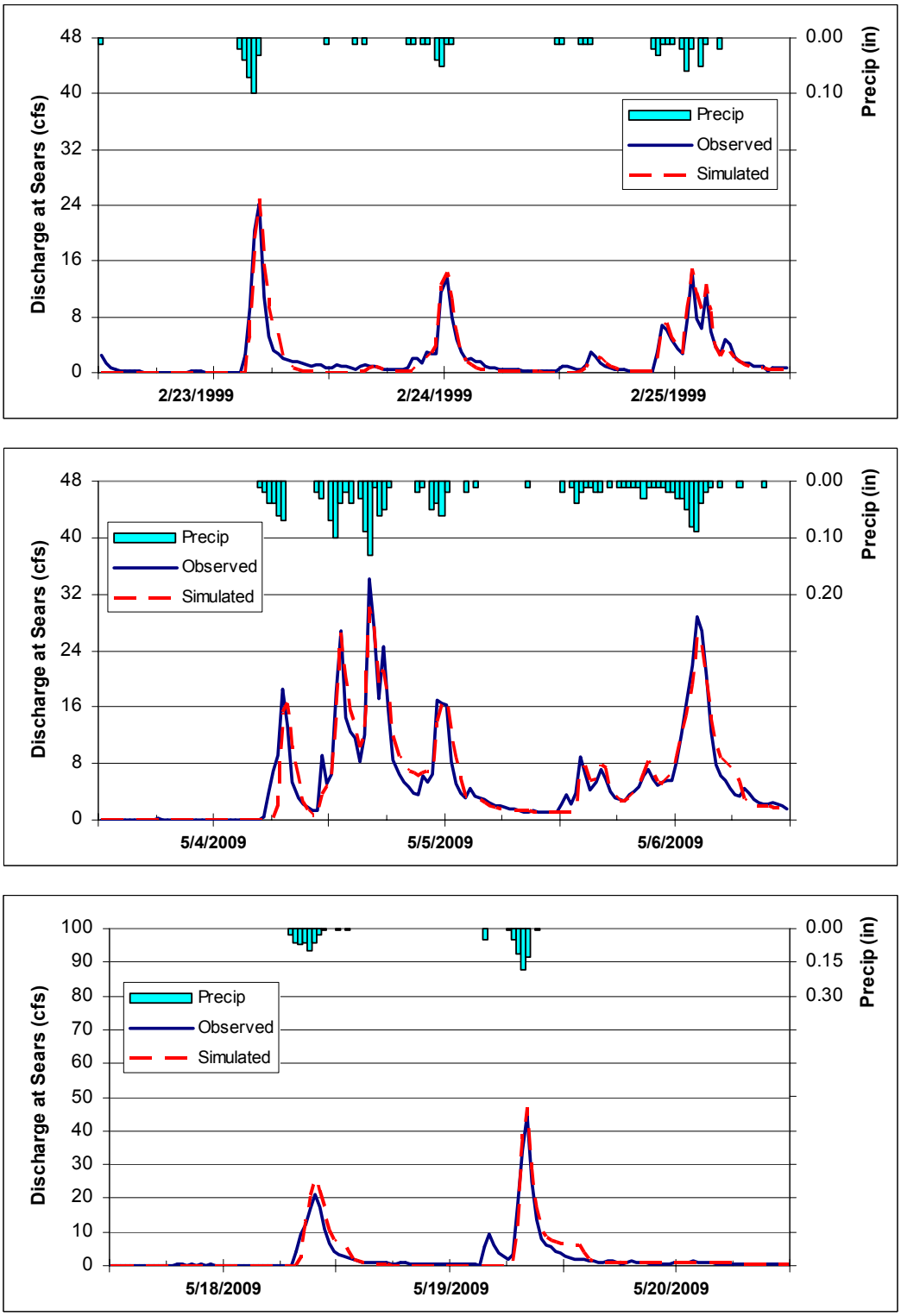
Model Validation versus Gaged Flows

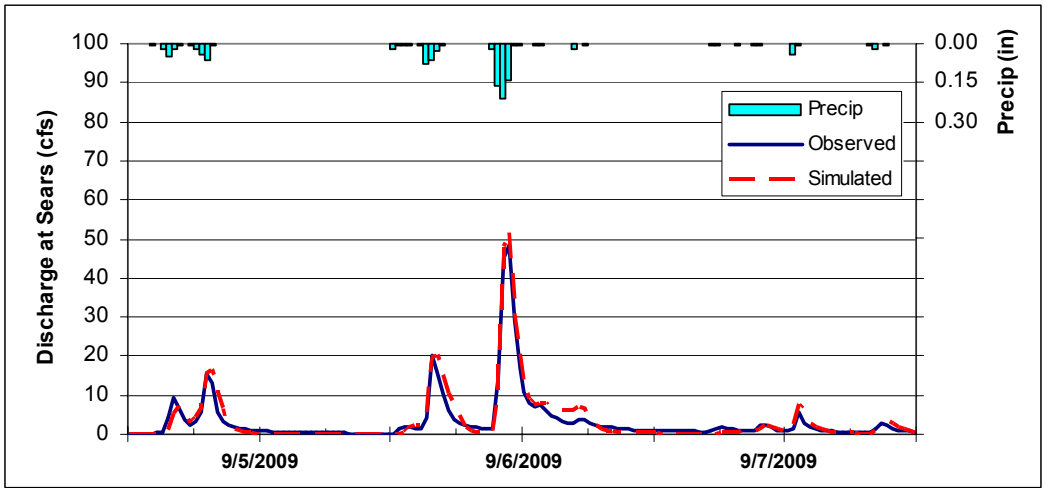
The updated existing conditions model was verified against observed flows at the gage in the Sears parking lot. This location receives stormwater from 95 percent of the study basin. The two largest events yet recorded occurred in September and October, since the last model validation was conducted. Model results and hydrograph comparisons are shown below in Table 1 and Figure 3. Note that the scales for the late May, September, and October events in Figure 3 differ from those for the earlier storms.

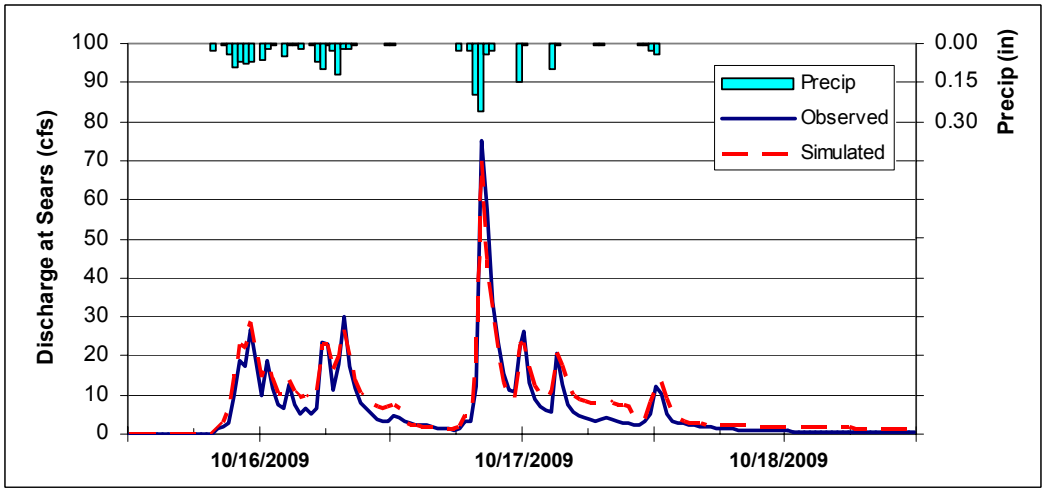
Table 1. Storm Peak and Volume Summary						
	Largest 30-min Peak Flow (cfs)			Event Volume (ac-ft)		
Period	Observed	Simulated	% Difference	Observed	Simulated	% Difference
Feb 23-25	24.2	24.8	2.5	12.2	11.9	-2.5
Mar 2-5	20.2	20.2	0.0	12.8	11.9	-7.0
Mar 25	17.6	19.4	10.2	12.3	12.2	-0.8
May 4-6	34.1	30.1	-11.7	32.6	33.1	1.5
May 13-14	19.3	19.9	3.1	11.3	10.1	-10.6
May 18-20	44.6	47.1	5.6	15.5	16.2	4.5
Sep 5-7	48.5	52.1	7.4	19.5	20.7	6.1
Oct 16-18[a]	75.1	70.1	-6.6	37.0	45.5	23.0
[a] Using adjusted peak rainfall values, based on radar analysis.						

As the table and figures (following pages) show, the model matches up well with event peaks and volumes for the events that occurred during the calibration period. Based on long-term simulations, the October event produced slightly larger than a two-year peak. Peaks are generally very well-simulated with no apparent systematic bias. Event volumes tend to be slightly high for the larger events, primarily due to extended recessions below 10 cfs compared to the gage. It is likely that this could be improved somewhat with improved representation of low flow hydraulics in the FTABLEs, though that effort is likely not necessary for the planned applications of the model.

Figure 3. Sample Model Verification Hydrographs




Discharge at Sears (cfs)
Precip (in)
Precip
Observed
Simulated
100
90
80
70
60
50
40
30
20
10
0
0.00
0.15
0.30
9/5/2009
9/6/2009
9/7/2009


Discharge at Sears (cfs)
Precip (in)
Precip
Observed
Simulated
100
90
80
70
60
50
40
30
20
10
0
0.00
0.15
0.30
10/16/2009
10/17/2009
10/18/2009